Comparison of Curved Root Canals Prepared with Various Chelating Agents

by

Kelli Swenson, LT, DC, USN

A thesis submitted to the Faculty of the
Endodontics Graduate Program
Naval Postgraduate Dental School
Uniformed Services University of the Health Sciences
in partial fulfillment of the requirements for the degree of
Master of Science
in Oral Biology

June 2012

Naval Postgraduate Dental School
Uniformed Services University of the Health Sciences
Bethesda, Maryland

CERTIFICATE OF APPROVAL

MASTER'S THESIS

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Kelli Swenson

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Thesis Committee:

Patricia A. Tordik, DMD
CAPT, DC, USN
Associate Dean, Graduate Dental Program
Navy Medicine Professional Development Center

Terry D. Webb, DDS, MS
CAPT, DC, USN
Chairman, Endodontics Dept.

Glen M. Imamura, DDS, MS
CAPT, DC, USN
Chairman, Dental Research Dept.

Glenn A. Munro, DDS, MS
CAPT, DC, USN
Dean, Naval Postgraduate Dental School

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Kelli Swenson

Kelli Swenson, DDS, MS
Endodontics Department
Naval Postgraduate Dental School
Uniformed Services University of the Health Sciences
01/01/2013

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Kelli Swenson, DDS, MS

ABSTRACT

Introduction: During instrumentation of a root canal, ethylenediaminetetraacetic acid (EDTA) as a chelating agents may be used during cleaning and shaping. EDTA demineralizes dentin and may inadvertently contribute to root canal transportation. The purpose of this study was to evaluate the effect of chelating agents used in moderately curved canals during instrumentation using micro-computed tomography (μCT) and imaging/modeling technology. **Methods:** Moderately curved mesiobuccal root canals of 18 de-identified maxillary molars were standardized in length and divided into 3 groups (n=6). Initial scans were taken using μCT. All canals were instrumented with Profile® (DENTSPLY Tulsa Dental, Tulsa, OK) 0.04 taper NiTi rotary instruments using saline, 17% EDTA (Pulpdent Corp., Watertown, MA) or RC-Prep™ (Premier Dental, Philadelphia, PA, USA). After instrumentation, lengths were re-measured and all the teeth were re-scanned. Using computer software, 3-dimensional models were created from the pre and post-instrumentation scans. Models were compared for changes in volume and transportation. **Results:** There was no statistically significant difference between the groups for any of the variables evaluated: working length (p=0.562), volume (p=0.079) and transportation (p=0.167 to 0.776). **Conclusion:** Under the conditions of this study, the use of chelating agents during instrumentation did not affect the size or position of the root canals.

Key words: EDTA, chelating agents, root canal preparation, transportation, micro-computed tomography

INTRODUCTION

One of the most important aspects of endodontic treatment is preparing the root canal (1). Proper cleaning and shaping provides access for irrigants to reach the entire canal length and provides space for medicaments and obturation materials. Over-instrumentation may lead to changes in canal anatomy which make it difficult to adequately obdurate the canal. In a study evaluating endodontic treatment of 2000 teeth, intra-operative complications were shown to have a negative impact on the outcome of initial treatment (2). In teeth where the canal anatomy is altered during retreatment, healing is significantly decreased compared to when canal anatomy is respected (3).

Teeth with complex root canal systems have a greater risk of procedural errors. Nearly all root canals are curved (4,5). Flexible endodontic files will straighten inside the root canal during instrumentation (6). Instrumentation of curved canals over prepare the outer wall of the curve near the apex and the inner wall of the curve near the crown (7). The reduced thickness of dentin in one direction results in stress distribution changes which may increase the risk of vertical root fracture (8).

During root canal instrumentation, chelating agents may be used. Many instrument manufacturers recommend using chelating agents as lubricants to decrease rotary instrument separation (9). Ethylenediaminetetraacetic acid (EDTA) was introduced for endodontic use by Nygaard-Ostby in 1957 to aid in narrow and calcified canal preparation (9). EDTA has a strong demineralizing effect. It softens dentin, enlarges dentinal tubules and denatures collagen fibers (9). Liquid chelator preparations are often used for smear layer removal. Paste or gel preparations are used as adjuncts during root canal preparation. A canal rinse with 17% EDTA followed by 5.25% NaOCl effectively removes the smear layer (9,10,11,). RC- Prep™ (Premier Dental, Philadelphia, PA, USA) is a common paste-type chelating agent combining 15% EDTA, 10% urea peroxide and glycol in an aqueous base (11). According to Bramante and Betti, instrumentation with NiTi hand files using EDTA caused greater deviation of the root canal from its original path in the apical third of curved canals (12).

Several experimental techniques study the effects of instrumentation on root canal anatomy. Micro-computed tomography (micro-CT) is a powerful imagining technology currently used to study canal morphology (7). It is nondestructive and allows detailed and accurate 3-dimensional imaging for comparison of canal anatomy before and after instrumentation (13). Micro-CT has also been used to map root canal anatomy (14), compare the shaping ability of different files (13,15), and evaluate the quality of obturation (16).

The purpose of this study was to compare the effects of chelating agents used to prepare moderately curved root canals of extracted maxillary first and second molars. Using micro-CT and imaging software, 3-dimensional models of root canals before and after preparation were constructed. Measurements were made before and after root canal instrumentation, to record changes in canal volume and length, and transportation.

MATERIALS AND METHODS

Preparation of Canals Eighteen maxillary first and second molars were selected from a collection of extracted teeth. The palatal roots were resected and discarded. Standard access cavities were prepared. An ISO 10 flexofile was inserted into the MB1 canal until it was flush with the apical terminus. Preoperative radiographs were taken and the curvature of the canals were determined using the method described by Schneider (17). Canals with fully formed apices and curvature of 10 to 30 degrees were included.

Using a digital caliper with 0.01mm resolution (Digimatic Caliper, Mitutoyo America Corp, USA) the length of the canals was measured. The length of the specimens was standardized to 19mm by reducing the coronal tooth structure and the working length was set to 18mm.

To aid in alignment of the 3-dimensional pre- and post-instrumentation models, 3 registrations points were made in the enamel of the crown using a #1/2 round bur. Each sample was mounted using Ultra-Mount™ (Buehler LTD, Lake Bluff, IL) in a modified polypropylene centrifuge tube (Thermo Fisher Scientific, Waltham, MA). The specimens were mounted horizontally and the distal root was embedded in compound. Mounting the specimens horizontally allowed for less time to scan and reconstruct the samples.

The specimens were randomly divided into three groups. The MB1 canal of each specimen was instrumented using a crown down technique with 0.04 taper Profile® (DENTSPLY Tulsa Dental, Tulsa, OK) nickel titanium rotary files to a master apical file size 30. Canals assigned to group 1 were irrigated with 2 mL 0.9% sodium chloride between each file. Canals assigned to group 2 were irrigated with 2 mL 0.9% sodium chloride between each file and the canals were flooded with 17% EDTA (Pulpdent Corp., Watertown, MA) prior to the use of each file. Canals assigned to group 3 were irrigated with 2 mL 0.9% sodium chloride between each file and RC-Prep™ (Premier Dental, Philadelphia, PA) filled the pulp chamber prior to the use of each file. The curvature of the canal, the volume of the chelating agent used and the time that it took to instrument the canals were recorded.

Micro CT Scanning and Measurements The specimens were scanned before and after instrumentation using a µCT-40 scanner (Scanco Medical, Bassersdorf, Switzerland) with an isotropic voxel size of 18 µm, set at 75 kVp and 114 µA.

Pre and post-instrumentation 3-dimensional canal models were constructed from the µCT data (Fig. 1) using MIMICS™ software (Materialise, Leuven, Belgium). The exact steps used to construct the pre-instrumentation models were recorded and used to construct the post-instrumentation models. The models were aligned using the external contours of the coronal tooth structure. Using 3Matic™ software (Materialise, Leuven, Belgium), the crown, pulp chamber, apical extent of the canal beyond working length, accessory canals and fins were removed from the models (Fig 1). This leaves only the portion of the main canal that was prepared by the rotary files to be evaluated for the change in volume and transportation (Fig 1). The volumes for the pre- and post-instrumentation models were calculated. The *center of gravity* was calculated at cross-sectional slices beginning at working length and moving coronally at 1mm increments. Canal transportation was calculated by measuring the distance between the centers of gravity of the pre- and post-instrumentation models at each cross section.

RESULTS

The curvature of the canals ranged from 21.1 to 29.89 degree with the mean curvature of 27.2, 26.2 and 27.4 degrees for the group 1, group 2, and group 3 respectfully. The working time for instrumentation ranged from 4min and 45 seconds to 14 minutes and 15 seconds. The volume of 17% EDTA used ranged from 0.20 mL to 0.35 mL and the volume of RC Prep ™ used ranged from 0.23 mL to 0.41mL.

The change in working length ranged from 0.01mm to 0.39mm. Mean changes in the working length are shown in Table 1. When the effect of the type of irrigant or chelating agent on the change in working length was evaluated a minute decrease was detected. Overall, the canals in which RC Prep™ was used during instrumentation showed the least change in working length (0.087±0.40), whereas those canals in which only saline was used showed the largest change in working length (0.185±0.206). Using a one-way ANOVA, on the basis of the p-value (0.562) there was no significant difference in these 3 groups.

The change in volume ranged from 0.247 mm^3 to 3.35 mm^3. Mean changes in volume are shown in Table 1. Canals that were instrumented with 17% EDTA as the chelating agent showed the largest change in volume (2.542 ± 0.886), where as those instrumented with RC-Prep™ showed the smallest change in volume (1.280 ± 0.568). The effect of the type of irrigant or chelating agent on the change in volume was evaluated using a one-way ANOVA. On the basis of the p-value (0.079) there is no significant difference between the three groups.

TABLE 1. Mean changes (± SD) in working lengths (mm) and canal volume (mm^3)

	Saline (n=6)	RC Prep (n=6)	EDTA (n=6)
Δ in Working Length	0.285±0.206	0.087±0.40	0.135±0.143
Δ in Volume	1.783±1.318	1.280±0.568	2.542±0.886

Transportation was measured at 1mm increments from working length to the coronal orifice. Transportation could not be measured in 3 samples due to unusual canal anatomy. All 3 samples belonged to the saline group. A two-way analysis was performed to determine if the effect of the type of irrigant or chelating agent used on the average transportation was the same at all levels of the canal. This was conducted comparing only three levels to include working length (D1), 4mm coronal to working length (D5) and 8mm coronal to working length (D9). The p-value was 0.751, which suggests that the effects of one factor were not different at the different levels of the other factor.

A one-way ANOVA was then conducted for each variable. The transportation between the levels of the canal was found to be significantly difference (p-value < 0.0005). A post-hoc analysis was conducted using the Tukey multiple comparison method. The difference was found between the apical and coronal levels and between the middle and coronal levels (p<0.0005). No difference was found between the apical and middle levels (p=0.486).

To determine if there was an effect of the type of irrigant or chelating agent used on the average transportation statistical analysis was conducted for the values at each level from working length (D1) to 8mm coronal to working length (D9). The mean transportation at each level is shown in Table 2. On the basis of the p-value (shown in Table 2) there does not seem to be an effect of the type of irrigant or chelating agent used at the different levels of the canal.

TABLE 2. Transportation (mm) after instrumentation measured at 1mm increments

	D1	D2	D3	D4	D5	D6	D7	D8	D9
Saline (n=3)	0.041	0.050	0.049	0.047	0.077	0.080	0.132	0.149	0.157
RC Prep™ (n=6)	0.026	0.019	0.029	0.034	0.038	0.059	0.098	0.109	0.121
EDTA (n=6)	0.044	0.077	0.067	0.086	0.059	0.066	0.073	0.122	0.178
p-value	0.361	0.332	0.256	0.167	0.251	0.776	0.357	0.690	0.327

DISCUSSION

Procedural errors have been shown to affect the outcome of endodontic treatment. Currently there is no evidence that shows that transportation has a direct effect on clinical outcomes (7). Canal transportation could lead to inadequately cleaned canals resulting in persistent apical pathosis, perforations or thinning of the canal walls leading to vertical fractures. This may lead to a need for surgical root canal treatment. Apical transportation >0.3mm was shown to negatively affect the apical seal in canals obturated by lateral compaction of gutta-percha (18), which could also affect clinical outcomes.

The anatomy of the canals preoperatively appeared to effect the change in volume and transportation. Retrospectively, the constriction of the canals were compared after a large difference in the change in volume was observed. The canals that were more constricted preoperatively had a larger change in volume and greater transportation.

Mean canal transportation ranged from 2.6µm to 17.8µm. Transportation was greatest in the coronal portion of the canal. This corresponds to the area of the rotary files that have the greatest mass and least flexibility. This may indicate that the physical properties of the file may be responsible for transportation versus the irrigant or chelating agent used.

The purpose of this study was to evaluate the effects of using EDTA during root canal preparation. To do this we chose to evaluate both RC-Prep™ and 17% EDTA, which is the highest concentration of EDTA commercially available. The use of 17% EDTA during instrumentation is not a standard protocol that we currently use as studies have shown that prolonged exposure can negatively affect the remaining tooth structure (10,19). In this study we are using a much smaller volume of EDTA than was used. The volume used may not be significant as Crumpton et al. found that there was no difference in the smear layer removal with varied volumes of EDTA (20).

In the study by Bramante and Betti, the authors do not define the concentration, volume or contact time of EDTA used. The results of this study are clinically confusing due to the undefined variables. It was still undetermined as to whether the use of EDTA during root canal preparation leads to procedural errors. The results of this study do not agree with their conclusion.

CONCLUSIONS

Under the conditions of this interim analysis, the irrigant or chelating agent used did not significantly affect the change in working length, change in volume and transportation. The change in volume approached statistical significance. In the author's opinion this is due to the uneven distribution of canals with constricted anatomy. With a larger sample size the p-value would most likely increase and further prove that the use of a chelating agent during instrumentation does not significantly affect the size and shape of the instrumented canal.

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